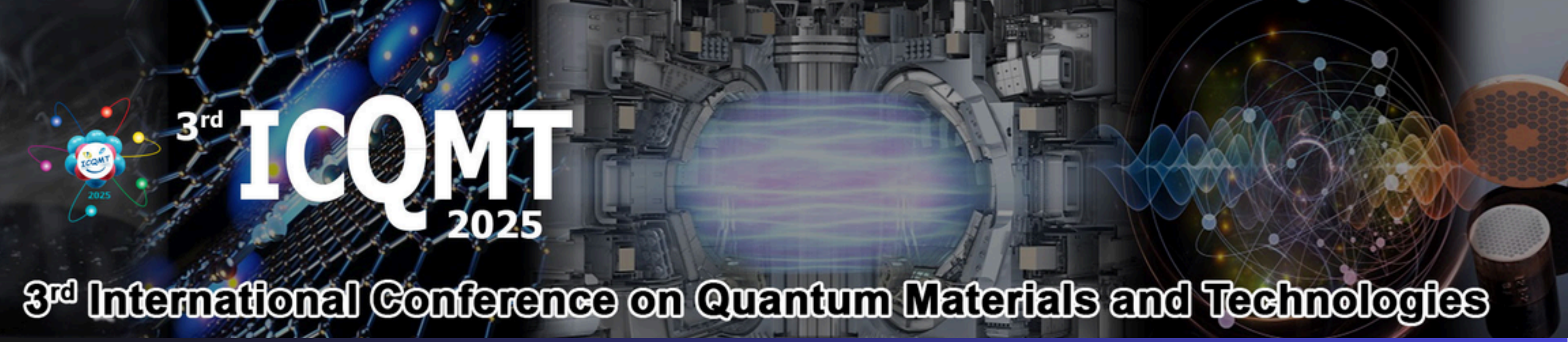


# Quantum Computing with Qubits

## Distinguished Professor Irfan Siddiqi

Irfan Siddiqi is the head of the Physics Department at UC Berkeley where he is the Douglas Giancoli Chair Professor. He is also a professor of Electrical Engineering and Computer Science, and a Faculty Scientist at Lawrence Berkeley National Laboratory. Irfan received his undergraduate degree in chemistry & physics at Harvard University, and a PhD in applied physics from Yale University and joined the Berkeley Faculty in 2005. His research group focuses on the development of advanced superconducting circuits for quantum information processing, including computation and metrology. Irfan is also the director of the Advanced Quantum Testbed at LBNL, which develops and operates full-stack quantum computing platforms based on superconducting qubits. He is known for key contributions to quantum measurement science, including real time observations of wavefunction collapse, tests of the Heisenberg uncertainty principle, quantum feedback, and the development of a range of microwave frequency, quantum noise limited amplifiers and detectors. Irfan is co-author of the book Quantum Measurement: Theory and Practice, a fellow of the American Academy of Arts and Sciences and the American Physical Society. He is the recipient of the APS George E. Valley prize and the Joseph F. Keithley Award. He is also a recipient of the Berkeley Distinguished Teaching Award—the university's highest award for commitment to pedagogy.

## Date and Time: From 26 April to 3 May 2025, exact day&time will be announced later.

## Lecture Room: TBD

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# Abstract

Quantum computing systems are rapidly maturing, giving rise to the exciting possibility of achieving computational advantage over classical technologies sooner rather than later. Typical quantum hardware utilizes qubits which are the two-state analogue of classical bits, albeit capable of being prepared in quantum superposition and entangled states, that yield a computational space that maximally grows as 2N for N qubits. Many quantum systems natively have more than two levels that can be utilized for information processing, thus permitting a more rapid growth of computing power, and a shorter route to quantum advantage, that may scale as dN for d levels. We demonstrate the experimental implementation of multi-level quantum computing protocols and algorithms in superconducting circuit-based quantum processors based on three and four levels. Key to the successful operation of such devices is the development of quantum ternary logical gates, efficient benchmarking techniques, and compiling. Leveraging advancements in novel microwave-based quantum control techniques, we efficiently generate highly-entangled states such as GHZ and atomic Schrodinger cat states with greater than 90 percent fidelity, develop a general scheme for synthesizing many-body gates such as the Toffoli, and show significant reduction in overhead when compiling quantum algorithms with qudits instead of qubits.


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